Food and feeding habits of the Caspian Kutum, *Rutilus frisii kutum* (Cyprinidae) in Iranian waters of the Caspian Sea

by

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ABSTRACT. - The feeding habits of Caspian Kutum, *Rutilus frisii kutum* (Kamensky, 1901), in Iranian waters were investigated by examining the stomach contents of 251 fish collected monthly from the commercial catch from October 2006 to April 2007. Their diet consisted of different prey, bivalves representing the most important prey group (59%), and *Cerastoderma lamarki* the dominant prey species (57%). By their decreasing order of importance, the others prey were: cirripeds (21%), gastropods (13%), malacostraceans (3%), fish eggs (2%), amphipods (1%) and filamentous algae (1%). Based on the frequency of occurrence *C. lamarki* was the main prey (F_i = 74.3%). In November, the fish fed on a wider variety of food items than in the other months. The lowest feeding activity was recorded in January and April. The gastrosomatic index (GaSI) ranged from 3.5% to 8.1%. Analysis of monthly variations in stomachs fullness indicated that feeding intensity fluctuated throughout the year, with lowest value in April, during the peak of spawning period.

RÉSUMÉ. - Habitudes alimentaires du kutum caspien, *Rutilus frisii kutum* (Cyprinidae) dans les eaux iraniennes de la mer Caspienne.

Le comportement alimentaire du kutum caspien, *Rutilus frisii kutum* (Kamensky, 1901), dans les eaux iraniennes a été étudié en examinant les contenus stomacaux de 251 individus échantillonnés mensuellement dans les captures commerciales d'octobre 2006 à avril 2007. Leur alimentation est composée de différentes proies, principalement de bivalves (59%), *Cerastoderma lamarki* étant la proie dominante (57%). Par ordre d'importance décroissante, les autres groupes de proies ont été : les cirripèdes (21%), les gastropodes (13%), les malacostracés (3%), les oeufs de poisson (2%), les amphipodes (1%) et les algues filamenteuses (1%). En terme de fréquence d'occurrence, *C. lamarki* a été la proie principale (F_i = 74,3%). En novembre, les poissons ont consommé une plus grande variété de proies que pendant les autres mois. La plus faible activité d'alimentation a été enregistrée en janvier et en avril. L'index gastrosomatique (GaSI) a été compris entre 3,5% et 8,1%. L'analyse mensuelle des variations de remplissage des estomacs a indiqué que l'intensité de l'alimentation a varié tout au long de l'année, avec des valeurs faibles en avril, pendant le pic de la période de reproduction.

Key words. - Cyprinidae - *Rutilus frisii kutum* - Caspian Sea - Iran - Diet.

Caspian Kutum (*Rutilus frisii kutum*) is the main component of Iran Caspian Sea fisheries. It represents over 50% of the total bony fish catch, and provided more than 60% of the fisherman's income (Abdolmaleki and Ghaninejad, 2007). The Caspian Kutum contributes substantially to the commercial fishery of southern Caspian Sea and is considered one of the most valuable fish in the country. This fish also contributes significantly to the commercial fishery of other countries bordering the Caspian Sea (Kuliev, 1997). The average annual catch of Caspian Kutum off the Iranian coast was about 9600 tons/year during the period 1991-2001 (FAO, 2003) and increased to 16000 tons in 2006 (Shilat, 2008). Since 1982, due to the reduction in *R. f. Kutum* population, and in order to rehabilitate the population of this valuable species in the Caspian Sea, the Iranian Fisheries Organization (IFO) has been releasing up to 200 million fry (average weight 1 g) into the rivers annually, which flow into the southern part of the Caspian Sea (Razavi Sayad, 1995).

The Caspian Kutum is a migratory anadromous fish spawning in rivers in March and April (Berg, 1964). Spawning migration of *R. f. Kutum* in Iranian Caspian Sea waters into the river takes place in March and April (Adeli Mosabbab and Piri, 2005; Afraei Bandpei *et al.*, 2007).

Despite its commercial importance, no studies have been carried out on the food and feeding habits of *R. f. Kutum* in the Iranian waters of the Caspian Sea specially in the central (Mazandaran province) and eastern (Golestan province) part of this region. Therefore, it is important to improve knowledge on the niche of this target species as a tool for stock management. The present study was carried out to investigate the feeding habits of *R. f. Kutum* in the southern Caspian Sea. The main objectives of the study were to describe diet, frequency of occurrence of different food items in the

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stomach, monthly changes in diet composition, feeding intensity, and feeding in relation to fish size.

MATERIAL AND METHODS

Study site

This research has been conducted in the southern Caspian Sea from early October 2006 to the middle of April 2007. From May to September fish catch was forbidden in the southern Caspian Sea. Fresh samples of *R. f. kutum* were collected from commercial beach seine catches in the southern part of the Iranian waters of the Caspian Sea (Mazandaran waters) (Fig. 1). The beach seine has 1200 m in length and 10-15 m in height, with a mesh stretched size of 3 cm in part of bag were hauled by tractor. They were hauled from shore to depth ranging 25-30 m. Water temperature in surface layer was 14.3 ± 5.14°C in average.

The salinity in the southern basin of the Caspian Sea ranges between 12 and 13 g/l (Kaplin, 1995). Current has a complex pattern and dominant general current pattern is from west to east and differs in summer compared with winter time. In western side the prevailing current directions are north to south while in the eastern side it is from south to north (Zaker *et al*., 2007).

Feeding indices

A total of 251 fish measuring 24-54 cm fork length (FL) and weight 160-1900 g were examined. The standard length (cm) and somatic weight (g) were recorded. Fish were opened and the degree of stomach fullness was estimated according to the subjective scale described by Lebedev (1946) as empty, ¼ full, ½ full, ¾ full, or full. The data were then used to calculate a monthly Fullness Index (FI).

FI = (Number of stomachs with the same degree of fullness / Total number of stomachs examined) x 100

The gut was then excised, weighed (g) together with its contents, and preserved in formalin 5% (72 hours) and after bath in 70% ethanol. Afterwards, stomach contents were suspended in water in Petri dishes and all prey were identified to the lowest possible taxonomical level using standard taxonomic keys (Birschetin *et al*., 1968). Diet composition was considered in terms of weight as well as numbers of prey organisms. For these purposes the following indices were applied (Hyslop, 1980):

Weight percentage of prey *i*: $[\%]W = (W_i / W_\Sigma) \times 100$

Numerical percentage of prey *i*: $[\%]N = (N_i / N_\Sigma) \times 100$

Frequency of occurrence: $[\%]F_i = (M_i / M_\Sigma) \times 100$

Where *Wi* is the weight (g) of prey group *I*, and W_Σ is the total weight (g) of prey detected, N_i is the number of prey specimen of prey group *I*, N_Σ is total number of prey detected, M_i is the number of stomachs containing prey component *I*, *M* is the number of stomachs containing food. When

Figure 1. - Map of the Iranian waters of the Caspian Sea, showing the fishing area.

$F_i > 50\%$ the prey group is considered the main prey, $50 > F_i > 10$ the secondary prey and $F_i < 10$ rare prey (Euzen, 1987).

The main food items were identified using the index of relative importance (IRI) as modified by (Hacunda, 1981):

$IRI = \%F \times (\%Cn + \%Cw)$

The index was expressed as:

$\%IRI = (IRI/\Sigma IRI) \times 100$

The extent of the diet was calculated using the diversity index of Shannon-Wiener (Ludwig and Rynolds, 1988),

$H' = -\Sigma P_i \times \log_2 P_i$,

where H' is the Shannon-Wiener index and p_i is the proportion by the number of prey type *i*.

The gastrosomatic index (GaSI) was calculated to investigate monthly variations in feeding intensity, using the equation (Biswas, 1993):

GaSI = (Fresh weight of stomach / Total fresh weight of fish) x 100

Data analysis

The results of the study were subjected to the following statistical analyses: post-hoc test, for testing the monthly variations in diet composition; χ^2, for testing the variation of empty stomachs over the year and frequency of occurrence. All calculations were carried out using SPSS 11.5 statistical software.

RESULTS

Food habits

A total of 3 genera of Bivalvia, one genus of Cirripedia, Gastropoda, Amphipoda, Malacostraca, Gobiidae, and as well as fish eggs and filamentous algae were identified in the stomach contents of *R. f. Kutum* from October 2006 to April 2007 (Tab. I). *Cerastoderma lamarki* was the main prey, constituting 92.6 % of the total IRI, followed by *Balanus* sp. (6.47%), *Hypanis* sp. (0.38%) and *Rhitropanopeus* sp.

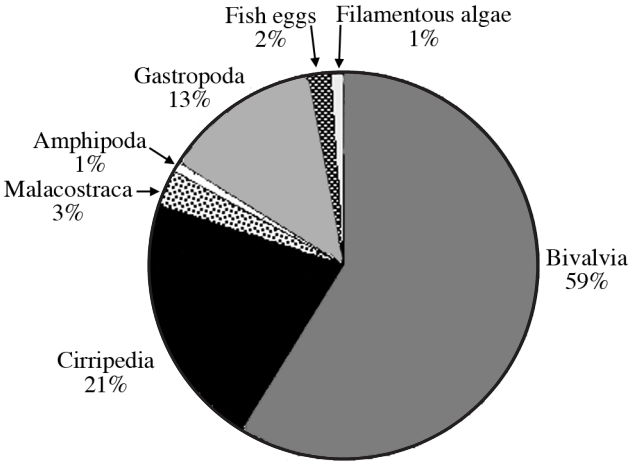

Figure 2. - Numerical percentage of prey in the stomachs of Caspian Kutum from October 2006 to April 2007.

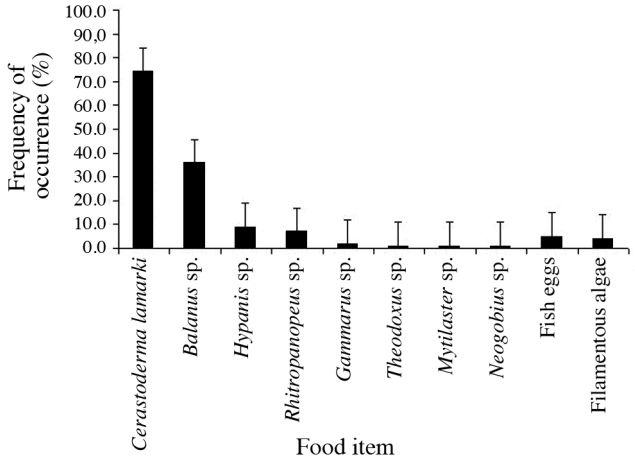

Figure 3. - Frequency of occurrence of different food items in the diet of *R. f. kutum* from October 2006 to April 2007. Note: Vertical bars indicate standard deviations.

Prey type	Frequency of occurrence (%)						
	Oct. 2006	Nov.	Dec.	Jan. 2007	Feb.	Mar.	Apr.
Bivalvia							
Cerastoderma lamarki	73.3	51.7	81.3	100	84.6	90.9	80
Hypanis sp.	0	3.5	6.3	0	15.4	0	0
Mytilaster sp.	0	13.7	0	0	0	0	0
Cirripedia							
Balanus sp.	13.3	37.9	31.3	20	23.3	50	40
Amphipoda							
Gammarus sp.	0	0	15.6	0	0	0	0
Gastropoda							
Theodoxus sp.	0	3.5	0	0	0	0	0
Malacostracea							
Rhithropanopeus sp.	13.3	3.5	34.3	0	3.8	0	0
Vertebrates							
Neogobius sp.	0	0	0	0	3.8	0	0
Fish eggs	0	6.9	6.3	0	0	9.1	0
Filamentous algae	13.3	3.4	0	0	0	0	0
Sample size	33	41	40	30	35	39	33

Table I. - Monthly frequency of occurrence of different prey types in *Rutilus frisii kutum* stomachs from October 2006 to April 2007.

(0.25%), while other food items like, *Theodoxus* sp., *Gammarus* sp., *Mytilaster lineatus*, *Neogobius* sp., fish eggs and filamentous algae, were rare (< 0.1%). The proportion of total prey types contributed to each prey group from October to April (Fig. 2) shows that the main component of the diet was Bivalvia, representing 59% of its diet.

Frequency of occurrence of different food items

Figure 3 shows the percentage frequency of occurrence (F_i) of different food items in the stomachs of *R. f. Kutum* for during the studied period. *Cerastoderma lamarki* represented the most frequent food item (74.3%). *Balanus* sp. represented a secondary prey (35.6%). The others food items were rare (less than 10%). A significantly difference between frequency of occurrence and food items was found ($\chi^2 = 262.1, p < 0.05$).

Monthly changes in diet composition

C. lamarki occurred the highest frequently in the stomachs during the study period (Tab. I). The variation of food items in the stomachs of Kutum was low in January and April which coincided with migration to deep area for wintering and migration to river for spawning, respectively. *Hypanis* sp. was found in November, December and February, while *Mytilaster* sp. was found only in November. *Balanus* sp. was found from October to April. Finally, the highest food items occurred in November and the least food items occurred in January and April. A significant difference was showed in the diet composition and monthly variations ($p < 0.05$).

Feeding behaviour related to fish size

The weight of stomach contents of *R. f. Kutum* in different size classes contributed from 28% to 85% to the fish wet weight. In the size class 25-30 cm stomach contents contributed with the highest percentage (85%) while in the 45-50 cm size class they contributed with the lowest percentage (28%). The stomach contents contributed with 53% in weight in the size class 30-35 cm, 29% in 35-40 cm, and 32% in 40-45 cm (Fig. 4). Bivalvia and Cirripedia dominated in the diet of all fish size classes. Shannon index ranged from 1.32 to 1.62. This index increased from 1.32 in the size class 25-30 cm to 1.53 in the size class 30-35 cm and to 1.62 in the size class 35-40 cm. Then it decreased to 1.34 in the size class 40-45 cm and to 1.28 in the size class 45-50 cm.

Feeding intensity

The gastrosomatic index (GaSI) of *R. f. Kutum* fluctuated in different months (Fig. 5). After a relatively decrease GaSI of 7.5 in October, an increase up to 7.8 and 8.1 was recorded in November and December, respectively. A decrease was observed in January (4.8), then increased in February (5.6) and March (5.1). The GaSI recorded the lowest value in April (3.5), which coincided to the peak of spawning migration of *R. f. Kutum* from Sea to river.

Monthly fluctuations were also showed by the percentage of occurrence of stomachs with different degrees of fullness (Fig. 6). From October to December the fish had ¼ full (22.1%), ½ full (18.0%), ¾ full (18.7%) and full (9.9%) stomachs. In January the degree of stomach fullness decreased to ¼ full (6.7%), ½ full (3.3%), and ¾ full (6.7%) which coincide with wintering of this species. From February to March, fullness increased ¼ full (13.3%), ½ full (20.1%), ¾ full (24.8%), and full (14.3%) stomachs. In April, the majority of the sampled fish 15.2% had ¼ full stomachs which coincided to peak of spawning migration to the river. Of the 251 stomachs examined, 117 (46.6%) were empty. The proportional of empty stomachs varied significantly among the month ($\chi^2 = 21.3$, $p < 0.05$). The maximum proportion of empty stomachs occurred in April (84.8%) and January (83.3%), while the minimum was recorded in December (20%) and February (25.7%).

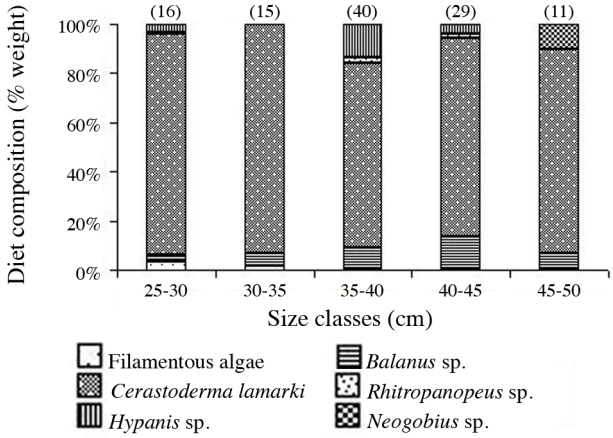

Figure 4. - Composition of *R. f. kutum* diet among size classes, based on weight percentage of prey. Number of stomachs examined in parentheses.

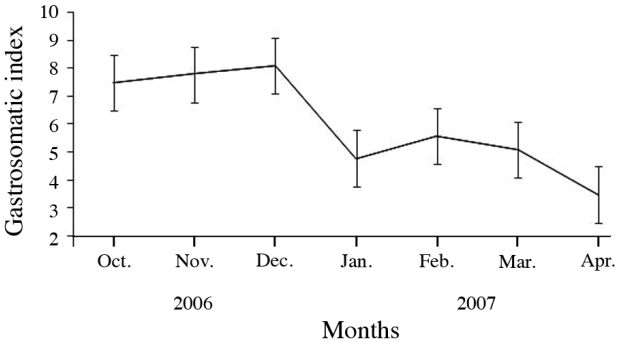

Figure 5. - Monthly variations in the gastrosomatic index of *R. f. kutum*. Vertical bars indicate standard deviations.

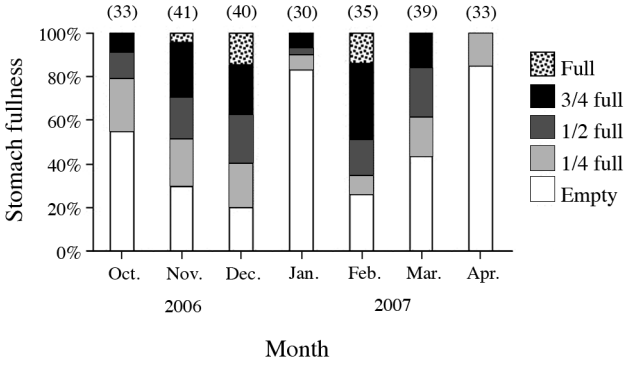

Figure 6. - Monthly variations in stomach fullness of *R. f. kutum*.

DISCUSSION

Our study, revealed that *Cerastoderma lamarki* was highly represented among the food items in the stomach contents of the Caspian Kutum. Similar results have been reported by Zarin Kamar (1996). This author found that the food of *R. f. kutum* in Guilan area (west of southern Caspian Sea) consists mainly of *Cerastoderma lamarki*, *Balanus* sp., and crabs while gastropoda, *Gammarus* sp., *Hypnis* sp. and *Abra* sp. were secondary preys. Oryan *et al*., (1998) noted also that *C. lamarki* is the main food of this species on the eastern and western coasts of Bandar Anzali, crabs and *Balanus* sp. were secondary prey.

On the contrary, Valipour and Khanipour (2006) reported that this species is generally omnivorous, feeding during the early life stages on phytoplankton, zooplankton and insect larvae, while during later stages, and after migrating to the

sea, it feeds mainly on bivalves (Valipour and Khanipour, 2006). In this study, the frequency of occurrence of *C. lamarki* in Kutum feeding is in accordance with Smirnova (1961) findings in which occurrence of *C. lamarki* in Kutum feeding attributed to the abundance of this bivalve in the region and morpho-ecological adaptation of *R. f. kutum* for consuming bivalves with hard shells. In the present study, filamentous algae were observed in the stomach contents in October and December. Khanipour (2005) reported that algae bloom occasionally occurred in summer and autumn after autumn circulation in southern coastal of the Caspian Sea. This bloom generally consists of Cyanophyta (genus *Nodularia* sp). This feeding behaviour could be due to the appearance of algae that was recognized by Khanipour (2005).

Zarbalieva (1987) reported that after entering the Sea, Kutum switch to a higher calorific diet composed predominately of crabs (*Rhithropanopeus harrisii*) with a 67.9-93.7% by weight. Molluscs, mainly *C. lamarckii*, constituted 30% by weight of the food of fishes of 30-40 cm. Fish larger than 40 cm rarely fed on molluscs but occasionally *Clupeonella* spp. In the present study, most of the analysed fish measured more than 25 cm due to commercial fishing and were located deeper than 15 m. This could be due to ecological location of area and temperature changes. In support, Wahbeh and Ajiad (1985) and Adel Aziz *et al*. (1993) reported that food consumption appears to be correlated to sea temperature, spawning activity, age, and available food items of the fish.

The stomach contents weight in relation to *R. f. kutum* size and weight showed that the smallest size class (25-30 cm) contained the highest food mass of 0.85% of body weight while the minimum food contents of 0.28% was recorded in large size class (45-50 cm). This could be due to the increase in feeding activity during grow out stages (Octobe-December) and the decrease in feeding activity during spawning season (March - April). It has also been reported that the lower consumption of older fish is probably related to a decreased rate of metabolism, since it is more beneficial for large fish to obtain more bulk at a lower rate of energy expenditure (Zarbalieva, 1987).

The pattern of feeding intensity investigated through the analysis of fluctuations in the stomach fullness indices revealed monthly variations. It was found that low feeding intensity in fish is synchronized with their spawning seasons, as has been reported by many authors (Stergiou, 1988; Kurup, 1993; Dadzie *et al*., 2007). The spawning migration of *R. f. kutum* in Iranian waters of Caspian Sea takes place in March and April, with a migration peak to the rivers being in April. However, there is generally an overlapping between spawning migration and fishing season in Iranian waters (Afraei Bandpei *et al*., 2007).

Available reports (Geetha *et al*., 1990; Dadzie, 2007) suggest that the high occurrence of empty fish stomachs during the spawning season is mainly due to the decreased feeding activity, since the mature gonads take up more space in the peritoneal cavity, compressing the stomach and making feeding activity more difficult. Similarly, Dadzie *et al*. (2000) reported that feeding is intensive during the early stage of maturity and decreases as the gonads mature. The feeding activity of Caspian Kutum in the present study also revealed monthly variations. Generally, low food values were recorded in January and April, while higher values were observed in December. The proportion of empty stomachs was high (46.6%). This could be due to industrial fishing activities; during fishing, when the trawling nets are full the fish are subjected to high pressure and may regurgitate (Ghadirnejad, 1996).

In conclusion, this study shows that *R. f. Kutum* is carnivorous, and feeds on a variety of prey items, and the diet and feeding behaviour changes by season, month, habitat and fish size. The high percentage of fish with empty stomach recommends that further research is needed, particularly from May to September.

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